THRUST 1 ADVANCED GUIDANCE

USER NEEDS

This Thrust focuses on the development of terminal seeker, sensor, and guidance technologies for weapons that can go anywhere, anytime, accurately, affordably, and autonomously. User needs have been extracted from the Air Combat Command (ACC) Mission Area Plans for Counter Air, Strategic Attack/Interdiction, Close Air Support/ Interdiction, Theater Missile Defense and Electronic Combat.

AIR-TO-SURFACE

Fixed Target/General Purpose Weapon Options (Direct and Standoff)

- Autonomous target identification and tracking in weather with affordable, countermeasure resistant seekers
- Real-time targeting and damage assessment
- Steep dive angle target acquisition and tracking
- Reduced mission planning requirements
- Minimal collateral damage
- Jam resistant Global Positioning System (GPS)/inertial weapon guidance

Mobile Target Weapon Options (Direct and Standoff)

- Autonomous target identification and tracking in weather with affordable, countermeasure resistant seekers
- Real-time targeting
- Identification of friend or foe
- Jam resistant GPS/Inertial weapon guidance

AIR-TO-AIR

Medium Range Missile Options

- Increased electronic countermeasure (ECM) resistance and broader target set
- Identification of friend or foe
- Capability against cruise missiles
- Improved guidance laws/autopilots for enhanced accuracy and faster intercept
- Low cost, small, and accurate Inertial Measurement Units (IMUs)

Short Range Missile Options

- High off-boresight lock-on and track capability with affordable seekers

See Figure 4 for major Thrust efforts.

GOALS

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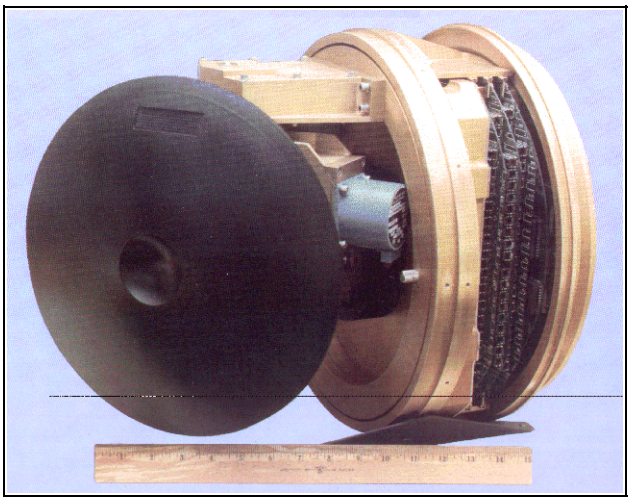

FIGURE 5. SYNTHETIC APERTURE RADAR SEEKER

The air-to-surface laser guided weapons currently in the inventory require designation of the target by laser. A successful mission requires not only that the designator remain in the target area until weapon impact but also that the weather is good enough to allow visual acquisition by both weapon and designator. Desert Storm highlighted this weather limitation and the need for precision guidance (minimum collateral damage). These considerations have led to the requirement for autonomous, all-weather, countermeasure resistant, precision seekers for our weapons.

- A near-term goal is to demonstrate a Synthetic Aperture Radar (SAR) seeker (Figure 5) capable of guiding a conventional direct attack weapon to a fixed high value target within 3 meters in adverse weather and at a cost of less than $40K per unit in quantities of 5000.

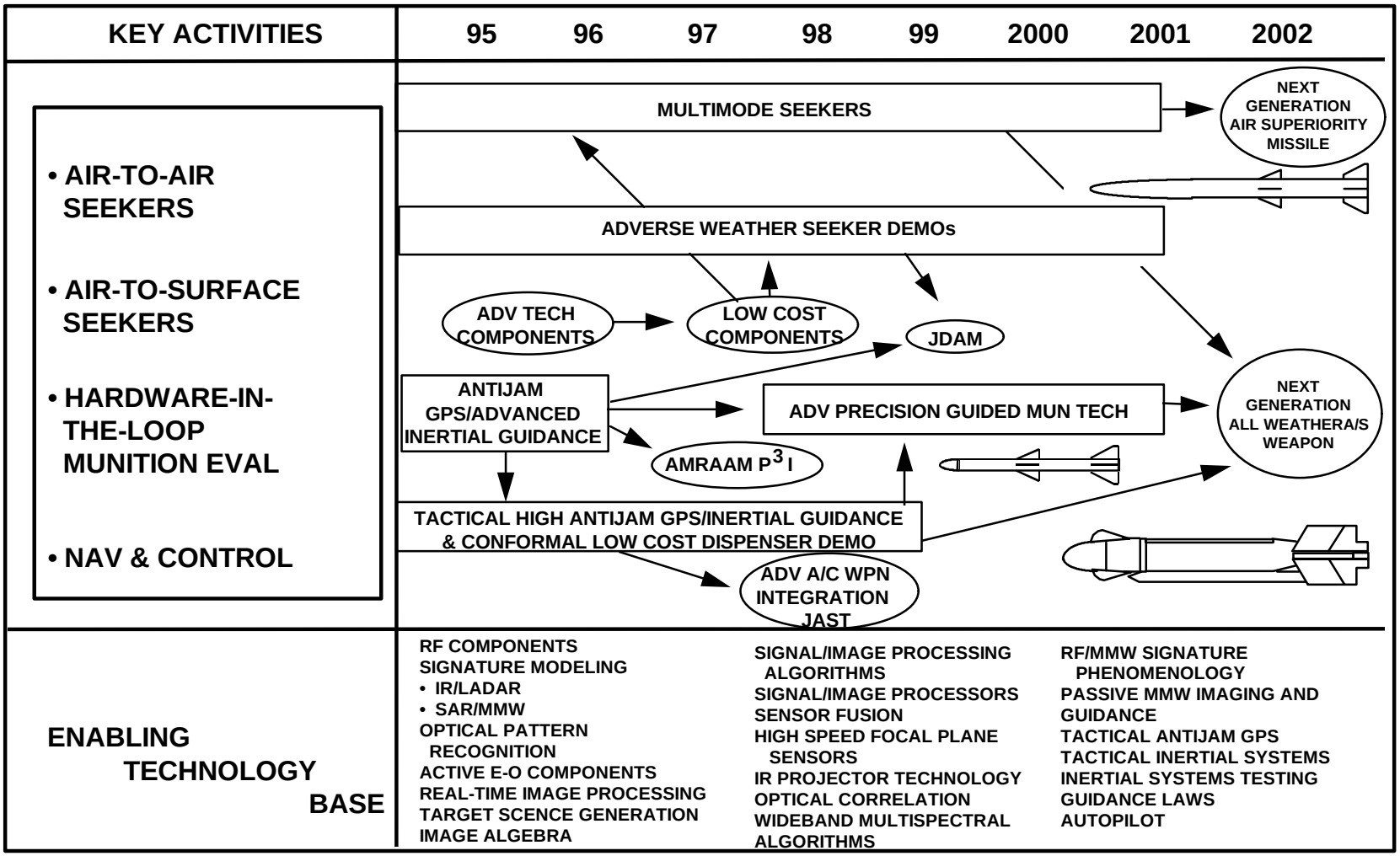

FIGURE 4. THRUST NO. 1 - ADVANCED GUIDANCE

Real-time targeting offers mission flexibility in a rapidly changing battlefield. It allows an update in the coordinates of a mobile target as well as the opportunity to change to an alternate high value target. Several techniques are being investigated to address this capability, to include using data from either on-board or off-board sensors. In addition, the seeker may use inputs from multiple types of sensors operating in different parts of the electromagnetic spectrum.

- A mid-term goal is to demonstrate real-time targeting for a SAR seeker using either on-board or off-board sensor information.

Acquiring and attacking fixed hard targets presents some unique problems. In order to employ penetrating weapons optimally, the seeker must be able to acquire the target in a steep dive angle and remain locked on until target impact. Also, detecting damage following attack is difficult, especially for buried or covered targets such as command control bunkers and aircraft shelters.

- Develop seekers capable of all-weather autonomous acquisition and precision tracking of fixed hard targets at steep dive angles.

- Develop and demonstrate methods to obtain real time battle damage assessment for fixed hard targets.

Traditionally, to mission plan for a strike against fixed high value targets with stand-off weapons can take up to several days. This timeline begins from receipt of targeting material through reference template generation to validation. Because of this, the number of sorties flown and targets attacked in a given time period is limited.

- Develop algorithms and user friendly tools which will reduce mission planning times from days to minutes to increase sortie generation.

Mobile targets such as tanks, trucks, relocatable missile launchers or radar sites have special seeker requirements for both stand-off and direct attack deliveries. To meet the user's need for defeating this broad spectrum of targets, an affordable laser radar seeker has been coupled with a multi-mode warhead in a maneuvering anti-materiel submunition. The seeker provides highly accurate guidance and enough information to determine which mode should be used to maximize lethality on the target.

- Develop an improved low cost seeker which combines autonomous target identification and tracking of mobile targets in weather with increased area coverage.

Distinguishing friend from foe when forces are in close contact is required for all-weather environments. To accomplish this task, the seeker must have precise angular and range resolution together with the capability to process at extremely high data rates.

- A mid-term goal is to exploit the technologies of high resolution laser radar, optical processing, and image algebra to develop new seekers. These seekers will have high speed, compact parallel processors capable of processing high resolution images in less than 10 milliseconds and algorithms which will find and identify targets in an adverse weather, clutter/ countermeasured environment, using high resolution solid-state laser radar sensors.

GPS/Inertial guided munitions are currently being developed for direct attack and stand-off applications. GPS/Inertial guidance provides a low cost, highly accurate, day/night, all weather guidance system for tactical weapons. GPS/Inertial weapon guidance, whether used alone or with a terminal seeker for precision accuracy, is the way of the future. But, jamming threats exist, and more are postulated. The intensity of jamming encountered by a weapon is more severe than that encountered by an aircraft because of the weapons proximity to collocated jammers at the target which could render the weapon GPS receiver useless, thus severely degrading weapon terminal accuracy.

- The goal is a low cost, small GPS/Inertial weapon guidance system for all weapon options which will be impregnable to jamming by all postulated threats.

- This thrust contains the only program within DOD that addresses the antijam GPS technology for tactical weapons. This technology supports the Joint Direct Attack Munition (JDAM) and all future tactical weapons.

Low cost, highly reliable, miniature IMUs are essential for all air-to-air and air-to-surface weapon

options, and for GPS/Inertial guidance systems. Current IMUs are large, expensive, and lack accuracy and reliability.

- Our goal is to develop, demonstrate, and mature a new generation of IMUs which are highly reliable, one-fourth the cost, and one-third the size of current systems. They will also have dual use potential for all types of commercial sensing devices.

AIR-TO-AIR

Efforts relating to medium range missiles are primarily concentrated on technologies to improve the AIM-120 AMRAAM. These include lower cost components, increased electronic countermeasure resistance against a broader target spectrum and identification of friend or foe.

- Develop a multi-mode seeker with enhanced processor hardware and algorithms to improve the target identification capability and end game accuracy.

- Provide enhanced performance against post-2000 advanced electronic countermeasures and low observable threats.

- Provide acquisition and shoot-down capability of cruise missiles.

There are current investigations under way to improve the performance of seekers for short range air-to-air missiles. The Armament Directorate is assisting in a number of technology areas to address the specific problems of high off-boresight lock-on and track with emphasis on reduction of component costs.

- Develop and demonstrate a low cost seeker with an electronic steerable conformal array antenna to provide rapid scanning of large fields-of-regard.

In addition to the target oriented goals listed above, there are goals for support technologies which apply across the board to all target types, for both air-to-air and air-to-surface. These include developing research test beds, modeling, and simulation tools which reduce development and life cycle testing while providing specific seeker performance information as well as overall reliability, maintainability, and supportability data.

- The goal is to develop advanced guided munition simulation and simulator technologies and techniques in order to provide reliable and affordable assessments early in the seeker development process. Advancements in simulator scene projectors, scene generation computer codes and hardware, flight motion simulators and real-time computer hardware will significantly increase the fidelity and utility of ground test facilities and reduce the magnitude of expensive flight test programs.

- To further the goal of identifying affordable concepts and components and reducing the life cycle cost of seekers, we are developing in-house research test beds. These include MMW Reflectivity Measurement Systems (MRMS), Research and Seeker Emulation Radar (RASER), a laser radar brassboard, a digital imagery workstation for mission planning applications, and the Advanced Guidance Research Facility (AGRF).

Missile effectiveness can be significantly increased by applying new target state estimation techniques, new guidance laws, and robust autopilot designs to optimize missile trajectories for faster intercept and increased terminal accuracy.

- The goal is a fully integrated guidance and control system which is capable of providing higher single-shot-kill-probabilities for missiles such as AMRAAM. An additional goal is the development of an innovative guidance law to replace the time honored but limited "proportional navigation" which was invented in 1948.

- This technology is also applicable to the air-to-surface area.

MAJOR ACCOMPLISHMENTS

Conducted captive flight testing and data collection of a SAR seeker in a steep dive trajectory. The data were analyzed to identify phenomenology and operational characteristics of operating a SAR guided weapon in a direct attack mode.

- Completed preliminary applications study of SAR seeker technology to the Joint Direct Attack Munition (JDAM).

- Initiated a FY95 new start program to integrate a SAR seeker onto an AGM-130 to demonstrate seeker-to-weapon integration and terminal accuracy.

- Used the digital imagery workstation developed under the Talon Scene program to explore methods to generate SAR templates using the Digital Point Positioning Data Base and other imagery products.

- Patented a High Speed Image Processor Architecture (HIPRA) in FY94 which is currently being evaluated for incorporation into a consortium with Martin Marietta for a program designated High Speed Algebraic Logic (HSAL) Commercialization.

- Developed and flight tested an optical correlator demonstrating the ability of an optical processor with ternary filters to identify ground targets in real time.

- Demonstrated three dimensional imaging of targets by a solid state-laser sensor at 10-kilometer range.

- Prototyped and demonstrated a suite of government owned, nonproprietary LADAR autonomous target acquisition/identification algorithms against a wide spectrum of critical mobile targets.

- Demonstrated Smart Tactical Autonomous Guidance (STAG) algorithm capability to perform transformation of images to other vantage points.

- Provided MRMS reflectivity data on competing camouflage nets to Joint Camouflage, Concealment and Deception SPO.

- Provided quick turnaround data analysis in support of the ARPA Technology Reinvestment Program Autonomous Landing Guidance program.

Completed five test entries involving infrared (IR) scene generation, injection, and projection to address the problem of designation and discrimination of Theater Missile Defense targets in the presence of debris.

- Established and defined new calibration methods for nonuniformity correction of resistor array IR projectors. Extensive testing demonstrated reliable highly repeatable calibrations. Nonuniformity corrections are critical for discriminating IR signatures with low intensities against low background clutter.

- Competed initial development and testing of a GPS antenna/filter which nulls jamming signals. Demonstrated jam resistance far exceeding current GPS antijam technology.

- Submitted two patent applications for new missile homing guidance laws. These guidance laws do not require an estimate of time-to-go and yield superior performance in detailed six degree-of-freedom simulations.

- Initiated a program to flight test an optical correlator sensor in a low cost unmanned air vehicle (UAV) flight test program.

- Began analysis of MMW target acquisition and tracking in active and passive modes as well as sensor fusion algorithms using the Modular Algorithm Concept Evaluation Tool (MACET).

CHANGES FROM LAST YEAR

- The Hammerhead program was approved for an FY95 start to provide a synthetic aperture radar seeker demonstration program for the Joint Direct Attack Munition Product Improvement Program (JDAM-PIP).

MILESTONES

AIR-TO-SURFACE

- Captive flight testing of the SAR weapon for the Hammerhead program will begin in FY97, followed by free flight demonstrations in FY97.
- Demonstrate real time targeting for a SAR seeker using either on-board and off-board sensor information in FY99.

- Captive flight tests of low cost solid-state laser radar seeker were flown against targets out to 10 kilometers in FY95.

- The optical correlator successfully tested in FY95 will be integrated with a laser radar. A flight test of this seeker to demonstrate target acquisition in a severe clutter environment will be conducted in FY96. The processor in the seeker will occupy less than 5 cubic inches and weigh less than 1 pound but have an equivalent processing capability better than a Cray computer.

- In addition to the optical processor, an all-digital image processing device is being developed. In FY95 the HSAL program was initiated to develop processor chips which can process the data equivalent to a full size television image in real-time using image algebra derived equations. Successful completion of the program in FY98 will provide a low cost programmable processor which can be used in future missile guidance systems.

- Design, develop, and build an adverse weather, wide field-of-regard, high resolution, passive, millimeter wave (MMW) sensor. This sensor is directed toward meeting user requirements for a covert seeker. Testing will be conducted in FY96 with program completion scheduled in FY97.

- Conduct RASER determinations of exploitable MMW phenomenology for the improvement of smart munition guidance systems in FY96.

- Explore active and passive real beam MMW imaging technologies in FY96 and FY97 for application to a covert air-to-surface seeker.

- Initiate a program to develop laser radar brassboard to evaluate new low cost components and algorithms which will provide the next generation, high resolution seekers in FY96.

- Version 4.0 of the computer code from the Infrared Modeling and Analysis (IRMA) program will be released at the end of FY95. This code allows realistic generation of spatially correlated active and passive infrared and active and passive MMW target and background scenes. In FY96 a new contract for Multisensor Modeling and Analysis (MSMA) will be let to continue Infrared Modeling and Analysis (IRMA) development to include the addition of new wavebands, sensor models, and air-to-air capabilities.

- Testing began in FY95 of a closed loop simulation of an infrared seeker that will generate in real time spectrally, temporally, spatially, and radiometrically correct target and background scene sequences. These sequences will be used to demonstrate a high fidelity infrared scene projector in FY97.

- In FY95 the digital imagery workstation developed under the Talon Scene program was used to explore methods to generate SAR templates using the Digital Point Positioning Data Base. In FY96 the results from this program will be applied to the precision SAR seeker development for direct attack munitions.

- In FY96 microchip laser sources will be tested and installed in laboratory research testbeds to determine applicability and performance gains. Microchip technology promises higher performance, lower cost, and reduced size.

- A GPS/Inertial guidance system with sufficient jam resistance to meet all postulated threats, costing less than $25K each and less than 200 cubic inches, will be delivered for ground testing in FY95. Flight testing of this key technology will be conducted in FY99. An advanced GPS/Inertial system capable of differential corrections which will cost less than $15K and is less than 100 cubic inches will be delivered for ground testing in FY99.

- In FY95 a fiber-optic gyroscope based IMU which will be 25 cubic inches and cost less than $6K each will be delivered for Air Force testing and integration. In FY99 a highly reliable, extremely small (less than 15 cubic inches), IMU which can be produced for less than $2K each will be delivered for Air Force testing and integration with advanced GPS/Inertial guidance systems and transferred to weapon Preplanned Product Improvement (P^3I) programs (e.g. AMRAAM, JDAM).

- Demonstrate active LADAR scene generation capability for integration into hardware-in-the-loop testing. Demonstrate concept feasibility in FY96. Integrate full-up system by FY99.

AIR-TO-AIR

- In FY96 apply signature modeling capability from the IRMA program and the codes from the Composite High Altitude Maneuvering Post-Boost Vehicle Program to air-to-air scene generation and analysis.

- Begin developing and testing affordable passive electro-optical/infrared, seekers which are sensitive to longwave infrared, multicolor, and polarization

signatures to provide improved air-to-air terminal seekers in FY98.

- In FY96 complete the conformal antenna design for the next-generation air superiority missile. Integrate the antenna with a high speed munition processor in FY97 and captive flight test the seeker in FY98.